SEMICONDUCTOR MECHANICAL SENSOR

This is a Divisional Application of application Ser. No. 09/749,693, filed Dec. 28, 2000, U.S. Pat. No. 6,463,803 which is a Divisional Application of application Ser. No. 08/834,129, now U.S. Pat. No. 5,872,024, filed Apr. 14, 1997, which is a Divisional Application of application Ser. No. 08/508,170, now U.S. Pat. No. 5,627,318, filed Jul. 27, 1995, which is a Divisional Application of application Ser. No. 08/109,504, now U.S. Pat. No. 5,461,916, filed Aug. 20, 1993, the entire contents of each being incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing a semiconductor mechanical sensor, and more particularly, to a method for manufacturing an acceleration sensor or a yaw rate sensor.

2. Description of the Related Art

As a semiconductor mechanical sensor such as an acceleration sensor, a yaw rate sensor, or sensors using piezoelectric ceramics are in wide use for attitude control of an automobile and to prevent jitter in a commercial video camera. In addition, Japanese Patent Publication Gazette No. 3-74926 discloses that two piezoelectric resistor elements arranged in parallel to a longitudinal axis of the cantilever, and in a side-by-side configuration, detects a force which corresponds to a rotation speed. In other words, without detecting deformation due to vibration of the cantilever, only deformation due to twisting of the cantilever is detected by the piezoelectric resistor element.

However, regarding accuracy, cost, etc., existing yaw rate sensors are not satisfactory, which restricts their application to other purposes.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve such a problem and to offer a semiconductor mechanical sensor having a new structure.

A further object of the present invention is to provide a method of manufacturing a sensor to improve the S/N ratio in such a semiconductor mechanical sensor having a new structure.

A still further object of the present invention is to offer a semiconductor mechanical sensor using a beam deflection type capacity detection method and a method of manufacturing the same, and to offer a semiconductor mechanical sensor which can detect mechanical changes in two or three directions (when two such semiconductor mechanical sensors are used) and a method of manufacturing the same.

To achieve these objects, basically, a semiconductor mechanical sensor according to the present invention has a structure as follows. That is, the semiconductor mechanical sensor manufactured according to the method of the present invention comprises:

a semiconductor substrate;

a beam which is formed on the semiconductor substrate, the beam having a weight; a first pair of electrodes one of which is formed on a first surface of the weight and another one of which is formed on a first surface of a wall of the substrate opposite to the same surface of the weight; and a second pair of electrodes which arranged perpendicular to the first pair of electrodes and one of which is formed on a second surface of the weight different from the first surface thereof and another one of which is formed on a second surface of a wall different from the first surface of the wall of the substrate, and opposite to the same surface of the weight.

In other aspect of the present invention, in addition to the above structure, the semiconductor mechanical sensor comprises: an AM modulation circuit for superimposing a signal from the physical force detect electrode onto a carrier wave; and a band pass filter for passing a signal from the AM modulation circuit whose center frequency coincides with the carrier wave.

In a further aspect of the present invention, a method of manufacturing such a semiconductor mechanical sensor comprises the steps of:

a first step of forming a groove of a predetermined depth in a main surface of a monocrystalline silicon substrate and perpendicular to the main surface thereof, to thereby form a beam which has a weight;

a second step of forming a pair of electrodes which face each other, one of which is provided on a side surface of the weight formed in a surface layer of the substrate and another one of which is provided on an inner surface of the groove opposite to the side surface of the weight, and forming another electrode on a surface of the weight in a direction which is perpendicular to the groove;

a third step of filling the groove with a filling material, forming an electrode on a bottom surface of the groove and opposite to the other electrode which is formed on the surface of the weight with the filling material interposed therebetween to thereby form another pair of electrodes, and of smoothing the major surface of the monocrystalline silicon substrate;

a forth step of combining the main surface of the monocrystalline silicon substrate with a separately prepared substrate;

a fifth step of polishing a back surface of the monocrystalline silicon substrate to remove a predetermined amount thereof to thereby make the monocrystalline silicon substrate thin; and

a sixth step of etching the filling material in the groove in the monocrystalline silicon substrate to thereby form the beam which has the weight.

In other words, in the semiconductor mechanical sensor manufactured according to the method of present invention, the weight which is formed at the tip of the beam is excited due to static electricity**7** which is created by applying an alternating current electric power to a side wall of the substrate which faces one surface of the weight. In such a state, in the axial direction of the weight, a change in the capacitance value between two electrodes arranged oppositely to each other is electrically detected so that a mechanical force which acts and changes in the same direction such as a yaw rate, an acceleration or the like is detected.

More precisely, in the semiconductor mechanical sensor according to the present invention, the weight is excited by static electricity due to alternating current electric power, and in the axial direction which is perpendicular to the direction of the excitation, a change in the capacitance value between the two electrodes arranged oppositely to each other, is electrically detected. The detected signal is superimposed on the carrier wave in the AM modulation circuit so that the carrier wave is AM modulated. Further, the signal from the AM modulation circuit is passed through the band pass filter which has a center frequency which coincides with the frequency of the carrier wave.